



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



ELSEVIER

Contents lists available at ScienceDirect

Best Practice & Research Clinical Anaesthesiology

journal homepage: www.elsevier.com/locate/bean



13

Healthcare at the time of COVID-19: A review of the current situation with emphasis on anesthesia providers



Martina Rekatsina, Anaesthetic Fellow ^a,
Antonella Paladini, Associate Professor ^b,
Eleni Moka, Consultant Anesthetist ^c,
Cheng Teng Yeam, Medical student ^d,
Ivan Urits, MD, Professor of Anesthesia ^e,
Omar Viswanath, MD, Professor of Anesthesia ^{f, g, h, i},
Alan D. Kaye, MD PhD, Professor and Chairman of Anesthesia ^f,
John A. Morgan, MD, Fellow of Anesthesia ^j,
Giustino Varrassi, MD, President ^{k, l, *}

^a Moorfields Eye Hospital, London, UK

^b Department MESVA, University of L'Aquila, L'Aquila, Italy

^c Creta Interclinic Hospital, Heraklion, Crete, Greece

^d Duke-NUS Medical School, 8 College Road, Singapore 169857, Singapore

^e Department of Anesthesiology, Critical Care and Pain Medicine, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, USA

^f LSUHSC School of Medicine, Department of Anesthesiology, Shreveport, LA, USA

^g Department of Anesthesiology, Creighton University School of Medicine, Omaha, NE, USA

^h Valley Anesthesiology and Pain Consultants-Envision Physician Services, Phoenix, AZ, USA

ⁱ Department of Anesthesiology, University of Arizona College of Medicine-Phoenix, Phoenix, AZ, USA

^j LSUHSC School of Medicine, Department of Obstetrics and Gynecology, Shreveport, LA, USA

^k Paolo Procacci Foundation, Via Tacito 7, Roma, Italy

^l World Institute of Pain, USA

Keywords:

COVID-19

anesthesiologist

nurse anesthetist

critical care

personal protective equipment

Coronavirus disease 2019 (COVID-19) is spreading rapidly around the world with devastating consequences on patients, healthcare workers, health systems, as well as economies. While, healthcare systems are globally operating at maximum capacity, healthcare workers and especially anesthesia providers are facing extreme pressures, something that is also leading to declining availability

* Corresponding author. Paolo Procacci Foundation, Via Tacito 7, Roma, Italy.

E-mail address: giuvarr@gmail.com (G. Varrassi).

and increasing stress. In this regard, it is extremely concerning the fact that some regions worldwide have reported up to 20% of their cases to be healthcare workers. When considering that the global case fatality rate may be as much as 5.4%, these numbers are concerning and unacceptable. As this pandemic accelerates, access to personal protective equipment for health workers is a key concern since at present, healthcare workers are every country's most valuable resource in the fight against COVID-19. Governments and health organizations should take care of their staff and support them in any way possible. This review aims to describe the current situation anesthesia providers are facing in the setting of COVID-19 and provide solutions and evidence on important concerns, including which guidance to follow, the level of equipment that is adequate, and the level of protection they need for every patient being administered an anesthetic.

© 2020 Elsevier Ltd. All rights reserved.

Introduction

During the coronavirus disease 2019 (COVID-19) pandemic, countries around the world have been experiencing lockdowns with grounded planes, sealed country borders, closed cities, and stay at home orders. It is clear that healthcare workers are experiencing a much different “fast forward” environment. Since January 2020, the life of healthcare providers in China has dramatically changed, and shortly thereafter, by mid-February those in Europe and the USA have been dramatically affected since COVID-19 spread to these regions and worldwide.

Aim

The aim of this investigation is to describe current numbers, current practice guidelines, and recommendations, and to provide answers to crucial questions which anesthesiologists, anesthetic nurses, and other healthcare professionals are facing. Since anesthesia providers are experts in airway management, they are on the frontlines of managing patients with COVID-19 and many of them have been called to serve roles in the intensive care unit (ICU) [1].

Methods

An initial search in official medical databases (PubMed, Medscape, Google Scholar) was conducted on April 1, in order to identify bibliography regarding the COVID-19 practice, guidance, and current situation that involves anesthetic doctors and nurses around the world. More searches followed until June 16. No specific criteria were set due to the limited sources available; however, daily searches in the same databases were being conducted. All articles were meticulously scanned in order to retrieve the most relevant information. However, related to the rapid evolving of the COVID-19 pandemic, most of the developments and updates could be only found by separate searches in the web, targeted to institutions, councils, or reliable news agencies.

Background

COVID-19 is an emerging and rapidly evolving worldwide pandemic [2]. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a formerly unknown type of coronavirus, was initially thought to be transmitted from animals to humans in the city of Wuhan in Hubei province, China, and is the cause of COVID-19. Its transmission probably started in November 2019 [3], but was officially

recognized by Chinese Government on December 31, 2019, as only then they reported a pneumonia of unknown cause to the World Health Organization (WHO) Country Office in China [4].

SARS-CoV-2 is, at present, unendingly spreading between humans all over the world. The outbreak was declared a Public Health Emergency of International Concern on January 30, 2020 [4] and on March 12, 2020, as a consequence of the rapid escalation of COVID-19, WHO declared a pandemic, and Europe has become the center of it [5]. The transmission is happening among symptomatic, pre-symptomatic, or asymptomatic carriers [6] and the spectrum of patients' symptoms varies greatly. The majority of patients with COVID-19 infection present with fever as the first symptom. Other common symptoms at onset of illness include loss of taste and smell, cough, or fatigue. Less commonly reported symptoms include palpitations, rash, headache, and diarrhea. A subset of patients develops dyspnea at days 5–8 after hospitalization, while the most commonly reported hematologic laboratory abnormalities with COVID-19 are leukopenia and lymphopenia [7]. The clinical spectrum ranges from asymptomatic to critically ill, and while the majority of patients have mild symptoms and good prognosis, approximately one in six patients will develop pneumonia, acute respiratory distress syndrome (ARDS), cardiac injury, renal injury, or multiorgan failure from days 7–10 after hospitalization. A subset of them will require admission to the ICU and respiratory support with noninvasive or invasive ventilation, or potentially extracorporeal membrane oxygenation (ECMO) [7].

Comorbidities that have been associated with severe illness and mortality include cardiovascular disease, diabetes mellitus, hypertension, chronic lung disease, cancer, and chronic kidney disease [8]. According to the report of April 9 from the Istituto Superiore di Sanità, in Italy from 1453 patients who died in a hospital, 3.5% of those had no comorbidities, 14.8% had a single comorbidity, 20.7% had two, and 61.0% had three or more [9]. Currently, it is known that the virus attacks human body through the angiotensin-converting enzyme-2 (ACE2) receptor, which is expressed by epithelial cells of the lung, intestine, kidney, and blood vessels [10,11]. Therefore, it is suggested that the different genetic basis of ACE2 expression and function in various populations might have its own role in the severity of illness; however, this remain still under investigation [11].

Way of transmission, viral load, and severity of disease

The highest viral load of SARS-CoV-2 is in saliva and upper airway secretions and is predominantly spread by droplet, usually sneezing or coughing (e.g., respiratory particles, generally above 5 μm diameter). It is also spread through contact routes, while airborne transmission occurs with smaller respiratory particles (e.g., generally < 1–500 μm or even up to 2000 μm). Spread is also seen during aerosol generating procedures (AGPs) including positive pressure ventilation, BiPAP, and CPAP, endotracheal intubation, airway suction, high-frequency oscillatory ventilation, tracheostomy, chest physiotherapy, nebulizer treatment, sputum induction, and bronchoscopy. These procedures increase the risk of healthcare worker infection and should only be undertaken when necessary. However, specific respiratory AGPs, like intubation, are of greater risk for anesthesia providers [12]. Therefore, techniques that reduce coughing, usage of positive pressure ventilation via an unsealed airway, and nil contact exposure to respiratory secretions will reduce risk.

Important to consider is the viral load of each patient that is being treated [7]. It is a fact that higher viral loads were identified on random sampling in individuals with greater symptom burden due to influenza [13], while greater mortality was also linked to higher viral loads in adenoviral pneumonia [14]. At the same time, moderate SARS-CoV-2 viral loads can be detected in nasal swabs up to 2 weeks after the onset of symptoms as well as in asymptomatic individuals [15]. However, Zhao et al. suggested that the attributable risk from higher viral inoculum is difficult to quantify in real-world settings, but higher viral loads in critically ill patients pose at least a theoretical risk to healthcare providers [16].

Current numbers of the disease and variations in mortality around the world

The data of the disease are devastating. On June 16, there were more than 7.9 million confirmed cases of coronavirus in 213 countries/territories, at least 435,000 people have died and slightly over 3 million have recovered. The United States had more confirmed cases than any other single country [17]. Very interesting is to shed some light to the fatality rate (number of deaths/number of confirmed cases)

around the world. In China, this rate is approximately 3.9%, while in Italy, it is reported to be just above 10%. One explanation could be that mortality is age-sensitive, and the Italian population is on average older than that of China [18]. Baud et al. suggest that the global case fatality rate may be closer to 5.4% [19], while the infection fatality rate (number of deaths/number of infections) could be as high as 0.9% [20]. The daily increase in deaths per capita is also an important consideration, with both Spain and the United Kingdom (UK) showing worse trajectories than Italy and the USA [18].

COVID-19 infection data between anesthesia providers and other healthcare workers

There is a great impact on healthcare workers that has been underpublicized. Data from the European Centre for Disease Prevention and Control (ECDC) show that of the confirmed cases in China, 3.8% were healthcare workers, while of those, 14.8% were severely or critically ill and 5% of the severe cases died. Meanwhile, in Spain, the latest COVID-19 situation overview from the Ministry of Health reports that 26% of COVID-19 cases are in healthcare workers. Moreover, in a Dutch study, healthcare workers were tested voluntarily for COVID-19 and 6% tested positive [21]. In another Chinese study conducted in February 2020, 54 medical staff of Tongji Hospital were hospitalized related to COVID-19. Most of them were from other clinical departments (72.2%) rather than emergency department (3.7%) or medical technology departments (18.5%). They reported that the distribution of age had a significant difference between non-severe type and severe/critical cases (median age: 47 years vs. 38 years, $p = 0.0015$). Their suggestion was appropriate personal protective equipment (PPE) for all medical and nursing staff, as well as appropriate training [22]. In Italy, Istituto Superiore di Sanità reported on April 10, that 10% of COVID-19 cases are healthcare workers, with Lombardy region reporting up to 20% of cases in healthcare workers [23]. In France, the public hospital system in Paris has tallied 490 infected staff members, a small but growing proportion of the system's 100,000 or so employees. The same dynamics are starting to take hold in Britain and the United States [24]. However, data still remain unclear as to whether mortality rates are greater in healthcare workers and studies are being undertaken in order to identify the relation, such as the study "intubate COVID" initiated by the Difficult Airway Society, in association with Guy's and St Thomas' NHS Foundation Trust [25].

On March 26, 2020, the Centre for Evidence-Based Medicine and more specifically the Oxford COVID-19 Evidence Service Team, gathered another data with reports across several countries, which demonstrated that healthcare workers are more at risk of being infected with SARS-CoV-2 and potentially more severely. They presented multiple sources, with considerable variation in the number of deaths reported, stating that the data presents a "confusing picture" [26]. However, according to the review, the evidence linking viral dose, viral load, and severity of disease is limited by the poor quality of many studies, the retrospective nature of the studies, small sample sizes, and the potential problem for selection bias [26]. These areas of uncertain evidence have left many healthcare workers confused, compound already high levels of anxiety, and may negatively impact clinical decision-making.

High stress levels and moral injury

Beyond the very distressing issues that many anesthesia providers are facing, another major problem is social isolation, which has kept them away from their loved ones for uncertain periods of time during COVID-19 [27,28]. Many anesthesiologists and nurse anesthetists have been pulled to the ICU for extended hours to address ventilator management and supplement existing critical care workforce manpower systems. Moreover, the social isolation might also be the result of stigma or fear from the general population [29]. Additionally, extremely difficult is the situation when health professionals have to face the imminent deaths of their patients or make and life decisions when rationing of limited resources, such as ventilators, is needed [29,30].

Recently, in China, researchers conducted a cross-sectional, geographically stratified survey of 1257 healthcare workers (39% physicians; 61% nurses) from 34 hospitals [31]. Although the survey did not specifically include anesthesia providers, this evidence could apply to them, as they are front line staff. The evidence of the study was overwhelming, as one third of the participants were suffering from distress, almost half of them were suffering from depression and anxiety, and one third of them had insomnia. As an answer to depression, anxiety, insomnia, and feeling of distress, team leaders, and

managers in health facilities should consider offering psychological support to any frontline health professional that needs it. In China, responding to such mental needs of their staff, some hospitals have developed psychological intervention plans with online courses and a hotline. However, initially many staff refused the psychological help. These staff were primarily interested in receiving uninterrupted rest with requests for enough protective supplies. However, over time, the training on skills to deal with patients' anxiety, panic, and other emotional problems was highly appreciated by the healthcare workers [32].

In the UK, the British Medical Association (BMA) has also addressed these delicate issues. They state that first-line health workers might have to make impossible decisions and work under extreme pressures. Some of these include allocating scant resources to equally needy patients, balancing their own physical and mental healthcare needs with those of patients, aligning their desire and duty to patients with those to family and friends, and providing care for all severely ill patients with constrained or inadequate resources [33]. As this might cause moral injury and mental health problems, healthcare managers need to proactively take steps to protect the mental wellbeing of staff. WHO is also giving mental health advice to healthcare workers, team leaders, and health facilities managers [34].

Worldwide surgical activity and recovery room models in COVID-19

Fortunately, elective activity has ceased in most of countries. For instance, in the UK, NHS England's chief executive announced in the middle of March that all non-urgent elective surgery would be suspended for at least 3 months in England [35]. The same decision was taken in Washington by its governor, who announced new restrictions on March 19, regarding non-urgent medical and dental procedures in order to reserve critical equipment (involving PPE) for COVID-19 healthcare workers [36]. Many countries have recently restored elective cases by early summer, 2020 in response to dramatic reductions in medical care unrelated to COVID-19. Further, many surgical societies have built pathways of pre-, intra-, and post-operative care for their patients undergoing urgent procedures or non-deferrable oncological interventions during the COVID-19 pandemic, in an attempt to reduce hospital visits and consequently the risk of contagion [37].

Though elective surgeries were cancelled in many countries, the question that might remain unanswered, whether the timeline was correct, or if it was too late. Regarding emergency cases, there is an ongoing debate related to the type of anesthetic to be employed, including regional anesthesia, wherever applicable, safer for both staff with less AGPs, as well as for better patient management with less opioid use postoperatively and less workload for staff [38].

While the current situation requires hospitals to turn into COVID-19 centers, new dedicated facilities are popping up in many countries redirected experienced staff, especially anesthesiologists and nurse anesthetists away from their hospitals in order to cover the surges of cases in other areas. In Belgium, despite having highly developed health system, Médecins Sans Frontières (MSF) were asked to support the country in key areas and provide their expertise on how to organize a hospital, as well as the flow of patients to prevent further COVID-19 surges in infections [39]. Similarly, the NHS in the UK has built Nightingale Hospital in London and is planning two more hospitals, one in Bristol and one in Harrogate [40]. In the United States, medical hospitals were created in a number of highly affected COVID-19 regions mostly reconfiguring large convention centers, two large navy medical ships were deployed to New York and California, and out of region staff were welcomed along with military healthcare experts [41].

Although these evolving models of healthcare for COVID-19 are recruiting all types of medical staff, their key frontline staff comprises anesthesiologists and nurse anesthetists, whose knowledge regarding airway management and mechanical ventilation is superior when compared with other medical fields. Of course, all of these developments are highly embraced both by the medical community, as well as the general population. However, a crucial question that remains is how many anesthesia providers will be left behind to provide for adequate emergency surgeries and for how long they will be able to work under pressure and many times with lack of adequate staff. Moreover, the reality has been that many healthcare workers, including anesthesia providers have become sick or needed to self-isolate for a couple of weeks through exposure to COVID-19, before coming back to the workforce [27]. According to some, it is ambitious and to an extent, a “gamble” to spread existing resources and staff even further [42], and this “spreading” is creating an additional imminent danger

which is how we should take into account the fact that anesthesia providers are markedly limited in many countries [43]. This is further supported by reports of Italian doctors that there are in limited and inadequate numbers to adequately help COVID-19 patients [44]. Another indication of the vast problem was an urgent call from the Governor of New York, to retired medical staff and qualified medical and nursing school students and staff encouraging their help, demonstrating inadequate personnel [45].

Dissemination of information

Social media have already integrated in medical community. Thus, it comes as no surprise that useful information is being shared through these platforms. However, the information being shared is not always consistent, as neither is equipment during the COVID-19 pandemic, demanding health workers to balance their own safety with limited supplies to protect them from infection [46].

There is a plethora of novel information and different approaches or guidelines that are being shared in official websites of Governments, Departments of Health, and Medical Professional Organizations and Committees, and also through social media. Generally, social media can clearly be used for education by sharing information, with or without videos and images and can inform clinicians before any publication does. Moreover, social media platforms can serve as a “conference meeting”, where experts can exchange opinion and discuss regarding crucial matters such as through webinars and group internet calls [47]. Another advantage of a social media platform is the easy and often open access of the contents, the reported self-improvement of clinicians through reading and listening to comments from experts and stakeholders, as well as dissemination of the latest recommendations in diagnosis and treatment of COVID-19 [48].

However, sharing important information through social media comes with drawbacks. During this pandemic, too many clinicians are providing commentary on COVID-19 patients and are sharing their own opinions or personal experiences that cannot always be applied widely across large regions or countries. In this regard, an article published recently in a French Newspaper [49] provided opinions that were very misleading from a less experienced clinician. Another example was a retracted article in June 2020 on the drug hydroxychloroquine was deemed inaccurate from *Lancet*. Moreover, although having large amounts of information easily found in a smartphone sounds convenient, gathering information from social media might prove dangerous if it is the source is not considered and carefully verified. Thus, the clinician should always consider the reliability of the source [50] and bear in mind two further issues regarding use of the internet and social media. Firstly, the distraction during work, known as “distracted doctoring,” which could be fatal for a patient [51]. Secondly, the possible stress that might emerge from unheralded headlines and abundant information (e.g., reports, colleagues' opinions, as well as their fears), regarding the pandemic along with diagnosis and treatment [52].

Which guidance to follow?

Taking also into account, all the different guidelines that are being rapidly published and with many of them being updated daily and weekly, a clinician would reasonably wonder, which guidance to follow. However, the answer is not easy. Although it is crucial for health workers to have guidelines, all these different sources from medical societies, medical boards, medicolegal unions, different societies, or even individual hospitals, along with the official or unofficial videos and webinars, are flooding clinician's input of information. Moreover, this might increase healthcare provider stress levels.

Cook et al. have noticed that several societies have established airway management guidelines, tried to provide summary pathways, applicable to all these guidelines, and have advised to use simulation whenever possible. They have also shared some key protection points for the providers, staff minimization, adapted preoxygenation and early paralysis, tips on the mask grip, and other tips to maximize odds of success [53]. Subsequently, it is prudent that whichever guideline an institution/team chooses to follow, a lot of simulations with available staff need to take place in order to minimize risks [54].

Another important issue regarding the guidelines being published is that they are referring to higher income countries. Therefore, most of the low- and middle-income countries will have to adapt the

information provided to their own realities and resources [46,55]. It is important to highlight that we have been encountering PPE shortages in countries with high economic status, such as the UK and the USA.

Is the PPE offered to staff right and adequate? Which type of mask should be used and what happens when we run out of PPE?

Access to appropriate PPE is of the highest priorities and the lack of it is perhaps one of the biggest threats. The Institute of Medicine, in 2006, stated that any strategy to cope with an influenza pandemic must be based on the knowledge and tools that are available at the time an epidemic may occur [56]. The above statement is definitely applicable to COVID-19 pandemic.

As it was earlier reported, even in one of the most economically strong countries, the USA, healthcare workers have been reporting shortage of equipment. Many healthcare workers have been told to turn in their masks and face shields at the end of his shift in order to be sterilized for future use or store their masks in a paper bag between shifts [57]. Tragically, most PPE is made in China and it appears that most of was sequestered for its own needs or sold to the highest bidder when countries have been in aggressive searches to replenish these important supplies. Moreover, according to “The Guardian”, doctors in Britain are being “bullied and shamed” into treating patients with COVID-19, despite not having the masks, gowns, and eyewear they need to protect themselves from the virus. It is widely accepted that this situation is of shame, and recently, Dr Samantha Batt-Rawden, the president of the Doctors' Association UK (DAUK) said that “... Lack of PPE continues to be a critical issue. It is heartbreaking to hear that some staff have been told to simply ‘hold their breath’ due to lack of masks” [58]. Being threatened when reporting the shortage to the public is also a reality [59].

DAUK has begun collecting anonymous reports from its network of frontline medics about continuing shortages of PPE with the help of a new mobile app. The shortages have created confusion, alarm, and fear among staff [58]. By April 6, 2020, they had 500 reports from 193 hospital trusts and general practitioners. Their report is nothing but disappointing. A total of 72% of doctors cannot get hold of a filtering facepiece class 3 (FFP3) mask (levels of mask protection will be discussed further in this article), when they need one, 77% report shortages of long-sleeved gowns, and 43% cannot always use a visor or goggles when they need them. The findings also indicate that protective kits are still in short supply for doctors undertaking “AGPs” on COVID-19 patients, such as airway manipulation, where almost half of the anesthesia providers cannot always access a gown, 42% an FFP3 mask, and 20% proper eye protection [58].

WHO is also recognizing that the shortage of PPE, related to rising demand, panic buying, hoarding, and misuse, is endangering health workers worldwide and calls on industry and governments to increase manufacturing by 40% to meet rising global demand [59,60]. Additionally, ECDC also clearly states that healthcare workers need to be protected as they are part of the critical infrastructure of response to this epidemic and need access to appropriate training on PPE use [61].

In the UK, the BMA, after being informed that supplies in two large areas of England were running at dangerously low levels, with unavailable pieces of equipment and putting doctor's lives at risk issued a report on April 10, 2020. They stated that the government is forcing doctors to place themselves and their patients in grave danger by expecting them to treat COVID-19 patients without adequate PPE, although they had previously reassured that supplies of PPE were plentiful, and that equipment was flowing out to trusts [62]. According to a recent survey by the BMA, more than half of doctors working in high-risk environments said that there were either shortages or no supply at all of adequate face masks, while 65% said that they did not have access to eye protection [63]. Furthermore, 55% said that they felt forced to work in a high-risk area despite not having adequate PPE. BMA's survey finds doctors' lives still at risk despite government pledges on PPE.

Dr Chaand Nagpaul, BMA council chair, has emphasized that “No doctor should ever have to be in harm's way when they go to work, and in these unprecedented times, this has never been more important.” He added that “This is not the flu. We are dealing with an unknown, highly infectious, and potentially deadly virus that has already claimed the lives of several healthcare workers, including 11 doctors in the UK. It is absurd that the people trained to treat this disease are the ones who are not being appropriately protected—and without them, we face real disaster.” He continued that no doctor should be facing the decisions over whether to carry on caring for patients without proper protection and put themselves and patients at risk [63].

Moreover, BMA has sent a clear message to their members, quoting that “Where you reasonably believe that your protective equipment is inadequate, you need to raise this urgently with your managers. Your manager should carry out a risk assessment and find alternative ways of providing the care and treatment. There are limits to the risks you can be expected to expose yourself to. You are not under a binding obligation to provide high-risk services where your employer does not provide appropriate safety and protection.” [64].

N95, FFP2, or FFP3 respirator?

Every healthcare worker deserves to have the proper equipment in order to continue treating patients. However, since there are many different guidelines regarding the proper level of equipment, which most of them are inconsistent, the guidance regarding the mask that should be used is unclear. The WHO, recommends the use of N95, FFP2 respirator, or equivalent for protection against coronavirus during AGP [65]. However, N95 is comparable with an FFP2 in assigned protection factor (APF), filter efficiency, and breathing resistance [66]. The required filter efficiency for an N95 is $\geq 95\%$, whereas for an FFP2 is $\geq 94\%$ and for an FFP3 is $\geq 99\%$.

According to the UK’s Health and Safety Executive (HSE) guidance, an FFP3 respirator, wherever there is risk of AGPs and at all times in ICU, intensive therapy unit (ITU), or high-dependency unit (HDU) where COVID-19 patients are cohoused, is required. Moreover, they demand that the users of the masks should have been fit tested before using the masks to fight any virus [66].

In the same country, after a lot of discussion between clinicians, committees, and organizations, in April, the Public Health England Organization, revised their guidance regarding COVID-19 PPE [67]. They suggested FFP3 masks for AGPs, along with a long-sleeved disposable fluid repellent gown (covering the arms and body) and a full-face shield or visor and gloves. Moreover, they recommended inclusion of individual and organizational risk assessment at local level to inform PPE use [67].

These days, it is a fact that a lot of healthcare workers have been reported to try to decontaminate their masks in order to reuse them in a later shift. However, according to the Institute of Medicine, without manufacturing modifications, current disposable N95 respirators cannot be effectively cleaned or disinfected and should therefore be discarded after a single use. Despite their statement about the constraints of reuse, they made a recommendation for extending the life of disposable N95 respirators for individual users, which is also consistent with the “Centers for Disease Control and Prevention’s Interim Domestic Guidance” on the “Use of Respirators to Prevent Transmission of SARS.” The commission recommended that if a disposable N95 respirator has to be reused, it must be protected from external surface contamination (e.g., using a surgical mask or face shield). In that way, the physical integrity and efficacy of the respirator will not be compromised but highly important is that appropriate hand hygiene before and after removal to be practiced [68].

On the same issue, in Europe, ECDC is highlighting the fact that research groups and healthcare facilities are currently looking into possible methods to decontaminate and sterilize masks (and other equipment) for reuse. However, they underline that none of these approaches has been standardized yet (such as steam, hydrogen peroxide vapor, ultraviolet germicidal irradiation, and gamma irradiation) [69].

Moreover, on the web, from twitter to medical websites, forums, and newspapers, a lot of DIY suggestions for creating “safe” masks with 3M filters, “hacking” full-face diving masks or using heat and moisture exchanger (HME) anesthetic filter with patient’s face mask [70–72]. Also, a very interesting work from the Asian Society of Pediatric Anesthesiologists is suggesting some “hacks” that could possibly replace the expensive and difficult to find equipment. For example, the authors are suggesting the usage of transparent plastic drapes in order to minimize aerosolizing during airway management, handmade face shields, scuba diving mask with viral filters, swimming/diving goggles, and garbage bags or raincoats as a protective gown [73]. However, all the above solutions are of doubtful quality and safety.

Considering all these suggestions, a health worker, which is not provided with the right equipment, approved by the responsible government organization, could arguably deny treatment of patients, in order to protect his/her own health, and the health of other patients. However, while FFP3 is the usual recommended control measure for AGPs, it may be reasonable to use an FFP2, if global supplies of FFP3 masks are low during a pandemic and this scenario is also consistent with the WHO guidance [65].

How to provide healthcare? How to perform surgery—Prepare as COVID-19 or not?

It appears that the incubation period of COVID-19, from infection to first symptom is 5–7 days, with a range of 4–14 days, whereas diagnosis of current infection relies on a reverse transcriptase polymerase chain reaction (RT-PCR) test, which detects virus in various body fluids. The testing protocols require substantial equipment, reagents, and expertise. Since asymptomatic shedding seems to be common, especially in children, the infection can be spread by anyone who arrives into the anesthetic room [74]. The fact that the results from oral swabs are unreliable is extremely worrying, as the total positive rate of RT-PCR for throat swab samples has been reported to be about 30–60% at initial presentation [75]. Moreover, it is important to highlight that there has been a shift from oral positive during early infection to anal swab positive during late infection can be observed. Also, patients infected with COVID-19 may harbor the virus in the intestine at the early or late stage of disease, clearly posing a threat to other people, as they will be considered negative [76].

In terms of general healthcare, overnight telemedicine has become the main format to see patients regardless of ailment during the current pandemic as it eliminates risk of exposure and spread of any infection, including COVID-19. A critical question that arises for the anesthetic teams is if they should follow the COVID-19 protocol for every patient and should that be a global direction given that rapid test kits though evolving are not universally available and, in some cases, have relatively poor sensitivity and specificity.

The major concerns are to prevent the staff from being infected and the fact that treating every patient has “presumed COVID-19 positive” would exacerbate the shortage of protective equipment. In our understanding, every acute and urgent surgery should be undertaken under a COVID-19 protocol unless proven to not be an infected patient. The answer is simply justifiable, since asymptomatic patients will have no history of disease, symptomatic patients might have a negative PCR test, and other infected patients might have uncommon symptoms, like diarrhea, and therefore, will not be tested for SARS-CoV-2 [7]. Focus has been centered around development of rapid testing kits in the emergency room, since many patients who end up in the operating room for emergency surgery originate there. In this regard, the Updated Intercollegiate General Surgery Guidance on COVID-19 in the UK clearly has recently stated: “Consider the possibility of COVID-19 infection in every patient, follow national guidelines and apply common sense to at risk clinical environments.” [77].

Conclusion

In this developing COVID-19 pandemic, while numbers are terrifyingly growing, the frontline staff will shoulder a tremendous responsibility for difficult clinical decision-making. Information regarding transmission of COVID-19, high levels of alert from both staff and managers, as well as adequate safe PPE are crucial and will help in both saving patients and medical health workers. Since, there is currently no indication at the EU/EEA level that the epidemic will end anytime in the coming months [21], a lot of patience and hard work is required.

Practice points

- Coronavirus disease 2019 (COVID-19) represents one of the most diffuse pandemics in the history of humanity, for sure the most diffuse of this century.
- This phenomenon is strongly interfering with many normal activities, also in the healthcare assistance, including anesthesia.
- Safety of the anesthesia personnel, both physical and psychological, is crucial.
- This paper focusses on some of the most important points that are of interest in the everyday practice.

Research agenda

- There are many reports on the effects of coronavirus disease 2019 (COVID-19) on the organization of the healthcare system. They are mostly correlated with intensive care and infectious diseases departments.
- Anesthesia would deserve a better attention on the interactions with COVID-19, considering that all the postponed routine surgical interventions of the last 4–6 months will soon be in the operating rooms, and will represent a potential source of stress for the healthcare professionals. Moreover, the patients are more and more interested to know what the potential interaction of anesthesia and COVID-19 might be.

Acknowledgment

Funding: This research has been possible thanks to an unconditional grant provided by the “Paolo Procacci Foundation-ONLUS,” Via Tacito 7, 00193 Roma, Italy.

Authorship: All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.

Author contributions: M. Rekatsina carried out most of the research and drafted the initial manuscript. All the authors have contributed to review and ameliorate the quality of the paper and have reviewed and approved the final draft of the manuscript.

Disclosures: None of the authors has potential conflict of interests with this publication.

Compliance with Ethics Guidelines: This article is based on previously conducted studies and does not contain any studies with human participants or animal performed by the authors without a previous Ethics Committee approval.

Open access: This article is distributed under the terms of the Creative Commons Attribution—NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any non-commercial use, distribution, and reproduction in any medium, provided you give appropriate credit to the original authors and the source, provide a link to the Creative Commons license, and indicate if changes were made.

References

- [1] Peng PW, Ho PL, Hota SS. Outbreak of a new coronavirus: what anaesthetists should know. *Br J Anaesth* 2020 Feb 27. <https://doi.org/10.1016/j.bja.2020.02.008>. pii: S0007-0912(20)30098-2.
- *[2] Pergolizzi J, Magnusson P, LeQuang JA, et al. The current clinical relevant findings on COVID-19 pandemic. *Anesth Pain Med* 2020;(April):e103819. <https://doi.org/10.5812/aapm.103819>.
- [3] Zhou P, Yang X, Wang X, et al. A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature* 2020;579:270–3. <https://doi.org/10.1038/s41586-020-2012-7>.
- [4] Rolling updates on coronavirus disease (COVID-19). World Health Organization; 2020. Accessed, <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen>. [Accessed 9 April 2020].
- [5] WHO announces COVID-19 pandemic. World Health Organization; 2020. Accessed, <http://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/3/who-announces-covid-19-outbreak-a-pandemic>. [Accessed 12 April 2020].
- [6] Coronavirus disease 2019 (COVID-19) situation report-73. World Health Organization; 2020. Accessed, https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200402-sitrep-73-covid-19.pdf?sfvrsn=5ae25bc7_2. [Accessed 2 April 2020].
- [7] Greenland JR, Michelow MD, Wang L, et al. COVID-19 infection: implications for perioperative and critical care physicians. *Anesthesiology* 2020 Mar 27. <https://doi.org/10.1097/ALN.0000000000003303>.
- [8] McIntosh K. Coronavirus disease 2019 (COVID-19), UpToDate, 2020. 2020. Accessed, <https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-clinical-features-diagnosis-and-prevention>. [Accessed 3 April 2020].
- [9] Report based on available data on April 9th Characteristics of COVID-19 patients dying in Italy. 2020. Accessed, https://www.epicentro.iss.it/en/coronavirus/bollettino/Report-COVID-2019_9_april_2020.pdf. [Accessed 9 April 2020].
- [10] Wan Y, Shang J, Graham R, et al. Receptor recognition by novel coronavirus from Wuhan: an analysis based on decade long structural studies of SARS. *J Virol* 2020 Mar 17;(7):94. <https://doi.org/10.1128/JVI.00127-20>. e00127-20 Print 2020 Mar 17.
- [11] Cao Y, Li L, Feng Z, et al. Comparative genetic analysis of the novel coronavirus (2019-nCoV/SARS-CoV-2) receptor ACE2 in different populations. *Cell Discov* 2020;6:11. <https://doi.org/10.1038/s41421-020-0147-1>. 2020 Feb 24 eCollection 2020.

- [12] Tran K, Cimon K, Severn M, et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One* 2012;7:e35797.
- [13] Hijano DR, Brazelton de Cardenas J, Maron G, et al. Clinical correlation of influenza and respiratory syncytial virus load measured by digital PCR. *PLoS One* 2019;14(9):e0220908. <https://doi.org/10.1371/journal.pone.0220908>.
- [14] Gu L, Qu J, Sun B, et al. Sustained viremia and high viral load in respiratory tract secretions are predictors for death in immunocompetent adults with adenovirus pneumonia. *PLoS One* 2016;11:e0160777.
- [15] Zou L, Ruan F, Huang M, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N Engl J Med* 2020. <https://doi.org/10.1056/NEJMc2001737>.
- [16] Zhao S, Ling K, Yan H, et al. Anesthetic management of patients with suspected 2019 novel coronavirus infection during emergency procedures. *J Cardiothorac Vasc Anesth* 2020. <https://doi.org/10.1053/j.jvca.2020.02.039>.
- [17] Coronavirus pandemic: tracking the global outbreak. BBC News; 2020. Accessed, <https://www.bbc.co.uk/news/world-51235105>. [Accessed 16 June 2020].
- [18] The (invisible) consequences of COVID-19. *The Anaesthesia Blog*; 2020. Accessed, <https://theanaesthesia.blog/2020/04/03/the-invisible-consequences-of-covid-19/>. [Accessed 3 April 2020].
- [19] Baud D, Qi X, Nielsen-Saines K, et al. Real estimates of mortality following COVID-19 infection. *Lancet Infect Dis* 2020 Mar 12. [https://doi.org/10.1016/S1473-3099\(20\)30195-X](https://doi.org/10.1016/S1473-3099(20)30195-X). pii: S1473-3099(20)30195-X.
- [20] Ferguson NM, Laydon D, Nedjati-Gilani G. Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand. Imperial College COVID-19 Response Team. Accessed, <https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf>. [Accessed 5 April 2020].
- [21] Coronavirus disease 2019 (COVID-19) in the EU/EEA and the UK – eight update. European Centre of Disease Prevention and Control; 2020. Accessed, <https://www.ecdc.europa.eu/sites/default/files/documents/covid-19-rapid-risk-assessment-coronavirus-disease-2019-eighth-update-8-april-2020.pdf>. [Accessed 8 April 2020].
- [22] Chu J, Yang N, Wei Y, et al. Clinical Characteristics of 54 medical staff with COVID-19: a retrospective study in a single center in Wuhan, China. *J Med Virol* 2020 Mar 29. <https://doi.org/10.1002/jmv.25793>.
- [23] Integrated surveillance of COVID-19 in Italy. *Epicentro (L'epidemiologia per la sanità pubblica)*; 2020. Accessed, https://www.epicentro.iss.it/en/coronavirus/bollettino/Infografica_10aprile%20ENG.pdf. [Accessed 10 April 2020].
- [24] Virus knocks thousands of health workers out of action in Europe. *The New York Times*; 2020. Accessed, <https://www.nytimes.com/2020/03/24/world/europe/coronavirus-europe-covid-19.html>. [Accessed 1 April 2020].
- [25] Intubate COVID project, difficult airway society and Guy's and St Thomas foundation trust. Accessed, <https://intubatecovid.knack.com/registry#project-details/>. [Accessed 7 April 2020].
- [26] SARS-CoV-2 viral load and the severity of COVID-19. Centre for Evidence-Based Medicine, University of Oxford; 2020. Accessed, <https://www.cebm.net/covid-19/sars-cov-2-viral-load-and-the-severity-of-covid-19/>. [Accessed 4 April 2020].
- [27] Doctors fear bringing coronavirus home: I am sort of a Pariah in my family. *The New York Times*; 2020. Accessed, <https://www.nytimes.com/2020/03/16/us/coronavirus-doctors-nurses.html>. [Accessed 2 April 2020].
- [28] Mental health and psychosocial considerations during COVID-19 outbreak. World Health Organization; 2020. Accessed, https://www.who.int/docs/default-source/coronaviruse/mental-health-considerations.pdf?sfvrsn=6d3578af_8. [Accessed 5 April 2020].
- [29] 13 deaths in a day: an 'Apocalyptic' Coronavirus Surge at a N.Y.C. hospital. *The New York Times*; 2020. Accessed, <https://www.nytimes.com/2020/03/25/nyregion/nyc-coronavirus-hospitals.html>. [Accessed 1 April 2020].
- [30] The Covid-19 crisis too few are talking about: health care workers' mental health. *Stat News*; 2020. Accessed, <https://www.statnews.com/2020/04/03/the-covid-19-crisis-too-few-are-talking-about-health-care-workers-mental-health/>. [Accessed 4 April 2020].
- [31] Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to Coronavirus disease 2019. *JAMA Netw open* 2020;3(3):e203976. e203976.
- [32] Raudenska Jaroslava, Steinerova Veronika, Javurkova Alena, Urits Ivan, Kaye Alan D, Viswanath Omar, et al. Occupational burnout syndrome and posttraumatic stress among healthcare professionals during the novel Coronavirus Disease 2019 (COVID-19) pandemic. *Best Pract Res Clin Anaesthesiol* 2020. <https://doi.org/10.1016/j.bpa.2020.07.008>. In this issue.
- [33] Greenberg N, Docherty M, Gnanapragasam S, et al. Managing mental health challenges faced by healthcare workers during covid-19 pandemic. *BMJ* 2020 Mar 26;368:m1211. <https://doi.org/10.1136/bmj.m1211>.
- *[34] Mental health and psychosocial considerations during the COVID-19 outbreak. World Health Organization; 2020. Accessed, https://www.who.int/docs/default-source/coronaviruse/mental-health-considerations.pdf?sfvrsn=6d3578af_8. [Accessed 7 April 2020].
- [35] Iacobucci G. Covid-19: all non-urgent elective surgery is suspended for at least three months in England. *BMJ* 2020 Mar 18;368:m1106. <https://doi.org/10.1136/bmj.m1106>.
- [36] Insee orders halt to elective surgeries and dental services to reserve critical equipment for COVID-19 health care workers. Washington Governor Jay Insee; 2020. Accessed, <https://www.governor.wa.gov/news-media/insee-orders-halt-elective-surgeries-and-dental-services-reserve-critical-equipment>. [Accessed 3 April 2020].
- [37] Simonato A, Giannarini G, Abrate A, et al. Pathways for urology patients during the COVID-19 pandemic. *Minerva Urol Nefrol* 2020 Mar 30. <https://doi.org/10.23736/S0393-2249.20.03861-8>.
- [38] How we will continue to regulate in light of novel coronavirus (Covid-19). General Medical Council; 2020. Accessed, <https://www.gmc-uk.org/news/news-archive/how-we-will-continue-to-regulate-in-light-of-novel-coronavirus>. [Accessed 2 April 2020].
- [39] COVID-19: MSF launched our largest ever response in Belgium. *Medicins Sans Frontieres*; 2020. Accessed, <https://www.msf.org/covid-19-msf-launches-its-largest-ever-response-belgium>. [Accessed 3 April 2020].
- [40] NHS to build more Nightingale Hospitals, as London set for opening. *NHS England*; 2020. Accessed, <https://www.england.nhs.uk/2020/04/nhs-to-build-more-nightingale-hospitals-as-london-set-for-opening/>. [Accessed 2 April 2020].
- [41] Faced with a crush of patients, besieged NYC hospitals struggle with life-or-death decision. *The Washington Post*; 2020. Accessed, <https://www.washingtonpost.com/health/2020/03/31/new-york-city-hospitals-coronavirus/>. [Accessed 2 April 2020].

- [42] Personal Protective Equipment (PPE) to protect you from COVID-19. What to wear and when. The Anaesthesia Blog; 2020. Accessed, <https://theanaesthesiablog.files.wordpress.com/2020/04/36755-ppe-guidance2020.pdf>. [Accessed 4 April 2020].
- [43] Dubowitz G, Detlefs S, McQueen KA. Global anesthesia workforce crisis: a preliminary survey revealing shortages contributing to undesirable outcomes and unsafe practices. *World J Surg* 2010;34(3):438–44. <https://doi.org/10.1007/s00268-009-0229-6>.
- [44] Two front line Italian COVID-19 doctors tell their stories of fatigue, sorrow – and hope. The Globe and Mail; 2020. Accessed, <https://www.theglobeandmail.com/world/article-two-front-line-italian-covid-19-doctors-tell-their-stories-of-fatigue/>. [Accessed 1 April 2020].
- [45] Andrew Cuomo @NYGovCuomo, URGENT! NYS is calling on recently retired health care professionals to sign up to be part of a reserve staff if the need arises. We also need qualified medical and nursing school students & staff. March 20, 2020. Accessed, <https://twitter.com/NYGovCuomo/status/1240798215663955968?s=20>. [Accessed 6 April 2020].
- [46] Cook TM. Personal protective equipment during the COVID-19 pandemic—a narrative review. *Anaesthesia* 2020 Apr 4. <https://doi.org/10.1111/anae.15071>.
- *[47] Schwenk ES, Chu LF, Gupta RK, et al. How social media is changing the practice of regional anesthesiology. *Curr Anesthesiol Rep* 2017;7(2):238–45. <https://doi.org/10.1007/s40140-017-0213-x>.
- [48] How to use social media in healthcare: a guide for health professionals. Hootsuite; 2020. Accessed, <https://blog.hootsuite.com/social-media-health-care/>. [Accessed 3 April 2020].
- *[49] Varrassi G. Warning against the use of anti-inflammatory medicines to cure COVID-19: building castles in the air. *Adv Ther* 2020. <https://doi.org/10.1007/s12325-020-01321-1> (published on internet April 1st 2020).
- [50] Schwenk ES, Chu LF, Gupta RK, et al. How social media is changing the practice of regional anesthesiology. *Curr Anesthesiol Rep* 2017;7(2):238–45. <https://doi.org/10.1007/s40140-017-0213-x>.
- *[51] Treat, don't tweet: the dangerous rise of social media in the operating room. 2017. Accessed, <https://psmag.com/social-justice/treat-dont-tweet-dangerous-rise-social-media-operating-room-79061>. [Accessed 2 April 2020].
- [52] Ventola CL. Social media and health care professionals: benefits, risks, and best practices. *Pharmacy and Therapeutics* 2014 Jul;39(7):491–520.
- [53] COVID-19: several societies establish airway management guidelines Cook TM & al. *Anaesthesia* 27 Mar 2020 curated by Jenny Blair, MD Clinical Essentials. 1 Apr 2020.
- [54] 'Think SIM' for your COVID-19 preparations. York and Humber Deanery NHS Trust; 2020. Accessed, <https://yorksandhumberdeanery.nhs.uk/sites/default/files/thinksimforyourcovid-19preparations.pdf>. [Accessed 5 April 2020].
- [55] Bong CL, Brasher C, Chikumba E, et al. The COVID-19 pandemic: effects on low and middle-income countries. *Anesth Analg* 2020 Apr 1. <https://doi.org/10.1213/ANE.0000000000004846>.
- [56] Institute of Medicine. Reusability of facemasks during an influenza pandemic: facing the flu. Washington, DC: The National Academies Press; 2006. <https://doi.org/10.17226/11637>. Accessed, . [Accessed 7 April 2020].
- [57] Nurses die, doctors fall sick and panic rises on virus front lines. The New York Times; 2020. Accessed, https://www.nytimes.com/2020/03/30/nyregion/ny-coronavirus-doctors-sick.html?fbclid=IwAR210h1LASV8jvu7riMn4YFO88jFgTXuiaOLoNvHt073L_xZ_TYqMWqmqJP0. [Accessed 7 April 2020].
- [58] Doctors lacking PPE 'bullied' into treating Covid-19 patients. The Guardian; 2020. Accessed, <https://www.theguardian.com/world/2020/apr/06/nhs-doctors-lacking-ppe-bullied-into-treating-covid-19-patients>. [Accessed 7 April 2020].
- [59] UK COVID-19 Daily: 'Doctors gagged over PPE shortages'. Medscape; 2020. Accessed, <https://www.medscape.com/viewarticle/927846>. [Accessed 1 April 2020].
- [60] Shortage of personal protective equipment endangering health workers worldwide. World Health Organization; 2020. Accessed, <https://www.who.int/news-room/detail/03-03-2020-shortage-of-personal-protective-equipment-endangering-health-workers-worldwide>. [Accessed 1 April 2020].
- [61] Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update. European Centre for Disease Prevention and Control; 2020. Accessed, <https://www.ecdc.europa.eu/sites/default/files/documents/RRA-seventh-update-Outbreak-of-coronavirus-disease-COVID-19.pdf>. [Accessed 2 April 2020].
- [62] Doctors forced into impossible situations as NHS staff report dangerously low levels of PPE. British Medical Association; 2020. Accessed, <https://www.bma.org.uk/news-and-opinion/doctors-forced-into-impossible-situations-as-nhs-staff-report-dangerously-low-levels-of-ppe>. [Accessed 11 April 2020].
- *[63] BMA survey finds doctors' lives still at risk despite Government pledges on PPE. British Medical Association; 2020. Accessed, <https://www.bma.org.uk/news-and-opinion/bma-survey-finds-doctors-lives-still-at-risk-despite-government-pledges-on-ppe>. [Accessed 11 April 2020].
- [64] COVID-19: PPE for doctors. British Medical Association; 2020. Accessed, <https://www.bma.org.uk/advice-and-support/covid-19/practical-guidance/covid-19-ppe-for-doctorsBritishMedicalAssociation>. [Accessed 11 April 2020].
- [65] Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19). World Health Organization; 2020. Accessed, https://apps.who.int/iris/bitstream/handle/10665/331215/WHO-2019-nCov-IPCPE_use-2020.1-eng.pdf. [Accessed 11 April 2020].
- [66] Research: Review of personal protective equipment provided in health care settings to manage risk during the coronavirus outbreak, Health and Safety Executive. 2020. Accessed, <https://www.hse.gov.uk/news/face-mask-equivalence-aprons-gowns-eye-protection-coronavirus.htm>. [Accessed 10 April 2020].
- *[67] Guidance COVID-19 personal protective equipment (PPE). Public Health England; 2020. Accessed, <https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control/covid-19-personal-protective-equipment-ppe>. [Accessed 9 April 2020].
- [68] Committee on the Development of Reusable Facemasks for Use During an Influenza Pandemic. Reusability of facemasks during an influenza pandemic: facing the flu. Washington, DC: The National Academies Press; 2006. p. 59–60. <https://doi.org/10.17226/11637>.
- [69] Rational use of PPE and hand hygiene materials for the care and management of COVID-19, European Centre for Disease Prevention and Control. Accessed, <https://www.ecdc.europa.eu/sites/default/files/documents/RRA-seventh-update-Outbreak-of-coronavirus-disease-COVID-19.pdf>. [Accessed 7 April 2020].

- [70] Heather Locklear @HeatherLocklear how to make N95 masks at home...by a medical professional. April 5 2020. Accessed, <https://twitter.com/HeatherLocklear/status/1246844984298557440?s=20>. [Accessed 6 April 2020].
- [71] How to make your own mask: Hong Kong scientists reveal temporary solution for those unable to get protective gear because of panic buying and price-gouging, South China Morning Post. 2020. Accessed, <https://www.scmp.com/news/hong-kong/health-environment/article/3050689/how-make-your-own-mask-hong-kong-scientists>. [Accessed 6 April 2020].
- *[72] Surgical innovation fellowship COVID-19: our response to the N95 shortage. Boston Children's Hospital; 2020. Accessed, <https://www.childrenshospital.org/research/departments-divisions-programs/departments/surgery/surgical-innovation-fellowship>. [Accessed 5 April 2020].
- [73] Low cost suggestions to creating or extending PPE. Asian Society of Paediatric Anaesthesiologist; 2020. Accessed, <https://aspa-2000.com/2020/03/27/low-cost-suggestions-to-creating-or-extending-ppe/>. [Accessed 5 April 2020].
- [74] Beeching NJ, Fletcher TE, Beadsworth MB. Covid-19: testing times. *BMJ* 2020;2020:369. <https://doi.org/10.1136/bmj.m1403>.
- [75] Ai T, Yang Z, Hou H, et al. Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. *Radiology* 2020;200642. <https://doi.org/10.1148/radiol.20200642>.
- *[76] Zhang W, Du RH, Li B, et al. Molecular and serological investigation of 2019-nCoV infected patients: implication of multiple shedding routes. *Emerg Microb Infect* 2020;9(1):386–9. <https://doi.org/10.1080/22221751.2020.1729071>. Published 2020 Feb 17.
- *[77] Updated intercollegiate general surgery guidance on COVID-19. Royal College of Surgeons; 2020. Accessed, <https://www.rcseng.ac.uk/coronavirus/joint-guidance-for-surgeons-v2/>. [Accessed 12 April 2020].